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(54) Invention Title: Heat Pump-Type Vehicular Heating and Cooling Apparatus

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Specification

1. Invention Title

Heat Pump-Type Vehicular Heating and Cooling Apparatus

2. What is Claimed is:

(1) A heat pump-type vehicular heating and cooling apparatus which is equipped with:

(a) an air duct to send air through to a passenger compartment,

(b) a hot water heater which is provided inside said air duct and which dissipates exhaust heat held in engine cooling water, and

(c) a refrigerating cycle device which is equipped with a first and second heat exchanger, whereas the first heat exchanger is provided at the downstream of said hot water heater in said air duct and functions both as a chilling medium evaporator which chills passing air during cooling operations and as a chilling medium condenser which heats passing air during heating operations, and whereas the second heat exchanger is provided at the downstream of said hot water heater in said air duct and functions as a chilling medium evaporator which chills passing air during heating operations.

3. Detailed Explanation of the Invention

[Field of Industrial Application]

The present invention relates to a heat pump-type vehicular heating and cooling apparatus in which a first and second heat exchanger of a refrigerating cycle device are provided at the downstream of a hot water heater in an air duct.

[Prior art]

Conventionally, there has been a heat pump-type vehicular heating and cooling apparatus in which heat in engine cooling water can be absorbed as a heat source to heat air, using a water chilling medium heat exchanger.

As shown in Figure 3, a refrigerating cycle device 100 of this heat pump-type vehicular heating and cooling apparatus is provided with a chilling medium compressor 101, a heat exchanger 102 which is placed outside of a passenger compartment and which functions as a chilling medium condenser during cooling operations, a liquid reservoir 103, an expansion valve 104, a heat exchanger 105 which is placed in the passenger

compartment and which functions as a chilling medium evaporator during cooling operations as well as a chilling medium condenser during heating operations, an expansion valve 106, a water chilling medium heat exchanger 107 which functions as a chilling medium evaporator during heating operations, and chilling medium pipes 108 which circularly connect these devices. Furthermore, in order to reverse circulating directions of the chilling medium between cooling and heating operations, a four-way valve 111, electromagnetic valves 112 and 113, and reverse flow check valves 114 and 115 are built in at designated locations in refrigerating cycle device 100.

Here, in order to absorb heat in the engine cooling water as a heat source for heating air, water chilling medium heat exchanger 107 of the above refrigerating cycle device 100 is provided inside a cooling water pipe 110 which is connected to a cooling water jacket for cooling of engine 109.

[Issues that Invention Attempts to Solve]

Yet, the prior art heat pump-type vehicular heating and cooling apparatus with the above constitution has problems in that holes appear in water chilling medium heat exchanger 107 or chilling medium pipes 108 due to corrosion and so forth, thereby the chilling medium flows into cooling water pipe 110.

When the chilling medium flows into cooling water pipe 110, the engine cooling water is pushed by the chilling medium. Then, cooling water pipe 110 may come off due to an increased internal pressure in cooling water pipe 110, and thus there is a concern in that the engine cooling water may likely leak.

The present invention aims to provide a heat pump-type vehicular heating and cooling apparatus which can prevent engine cooling water from leaking even when holes appear in the second heat exchanger.

[Means to Resolve Issues]

A heat pump-type vehicular heating and cooling apparatus of the present invention adopts a constitution in which the heat pump-type vehicular heating and cooling apparatus is equipped with:

an air duct to send air through to a passenger compartment,

a hot water heater which is provided inside said air duct and which dissipates exhaust heat held in engine cooling water, and

a refrigerating cycle device which is equipped with a first and second heat exchanger, whereas the first heat exchanger is provided at the downstream of said hot water heater in said air duct and functions both as a chilling medium evaporator which chills passing air during cooling operations and as a chilling medium condenser which heats passing air during heating operations, and whereas the second heat exchanger is provided at the downstream of said hot water heater in said air duct and functions as a chilling medium evaporator which chills passing air during heating operations.

[Operations and Advantages of Invention]

A heat pump-type vehicular heating and cooling apparatus of the present invention employs the above constitution operates as follows and has the following advantages.

The second heat exchanger which functions as a chilling medium evaporator to cool passing air during heating operations is provided at the downstream of the hot water heater inside the air duct. The second heat exchanger exchanges heat between the engine cooling water and the chilling medium across air. Thus, the engine cooling water can be prevented from leaking even when holes appear in the second heat exchanger and others.

[Embodiments]

Examples of a heat pump-type vehicular heating and cooling apparatus according to the present invention is explained based on Figure 1 and Figure 2.

Figure 1 shows a refrigerating cycle device of an automotive heat pump-type heating and cooling apparatus to which Example 1 of the present invention is applied.

Reference designator 1 denotes an automotive heat pump-type heating and cooling apparatus (hereafter, abbreviated as a heating and cooling apparatus).

Heating and cooling apparatus 1 was provided with an air duct 2 to pump air through to a passenger compartment (not shown in the figure), a hot water circuit 4 through which engine cooling water circulated, and a refrigerating cycle device 5 in

which a cooling operation and a heating operation could be switched by reversing the circulating direction of the chilling medium.

For air duct 2, an inlet 21 was formed at the upstream of the airflow through which air from outside of the passenger compartment is introduced, and an outlet (not shown in the figure) was formed at the downstream of the airflow through which air is pumped into the passenger compartment. In addition, inside air duct 2, a ventilator 3, a hot water heater 41 for hot water circuit 4, a first heat exchanger 51 and a second heat exchanger 52 for refrigerating cycle device 5 were provided sequentially from the upstream to the downstream of airflow.

Ventilator 3 has a fan 31 which introduced air through inlet 21 and which generated airflow inside air duct 2 toward the passenger compartment and a drive motor 32 to drive said fan 31.

In hot water circuit 4, engine-cooling water which was heated in a water jacket for cooling an engine 10 was supplied through cooling water pipe 42. Moreover, hot water circuit 4 was equipped with hot water heater 41 and a water valve 43.

Hot water heater 41 was provided inside air duct 2 at the upstream of first heat exchanger 51 and the second heat exchanger 52, and dissipated engine exhaust heat which was contained in the engine cooling water at high temperatures, thereby heating passing air and air inside the passenger compartment.

Water valve 43 was provided in cooling water pipe 42 and controlled the flow of the engine cooling water into hot water heater 41. Water valve 43 closed in order to stop the supply of the engine cooling water to hot water heater 41 when an heating and cooling switch lever (not shown in the figure) on a control panel was turned to the cooling operation position, and the valve opened in order to supply the engine- cooling water to hot water heater 41 when the lever was turned to the heating operation position.

Refrigerating cycle device 5 is equipped with first heat exchanger 51, second heat exchanger 52, a chilling medium compressor 53, a chilling medium condenser 54, a liquid reservoir 55, a temperature activated expansion valve for heating 56 which is made up as a pressure reduction device for the chilling medium, a temperature activated expansion valve for cooling 57 which is made up as a pressure reduction device for the chilling medium, reverse flow check valves 58 and 59, electromagnetic switching valves

(hereafter abbreviated as electromagnetic valves) 60 and 61, a four-way valve 62 and chilling medium pipes 63 which connected these devices.

First heat exchanger 51 was provided inside air duct 2 at the downstream of airflow from hot water heater 41. It functioned as a chilling medium condenser which chilled and condensed a vapor phase chilling medium with a high temperature and a high pressure which chilling medium compressor 53 provided during heating operations. The chilled air, which fan 31 introduced, was heated while it passed through first heat exchanger 51.

In addition, heat exchanger 51 functioned as a chilling medium evaporator in which during a chilling operation, a chilling medium in a mist form with a low temperature and a low pressure from expansion valve 57 absorbed heat from the surrounding air and evaporated. The heated air introduced by fan 31 passed through first heat exchanger 51 and thereby was chilled.

Second heat exchanger 52 was provided inside air duct 2 at the downstream of airflow from first heat exchanger 51. A chilling medium in a mist form with a low temperature and a low pressure came from expansion valve 56 in cooling operations in which electromagnetic valve 60 was open during heating operations. Second heat exchanger 52 functioned as a chilling medium evaporator in which the chilling medium absorbed heat from the air at a high temperature which passed through hot water heater 41 and first heat exchanger 51 and thereby evaporated.

Activated by engine 10 through an electromagnetic clutch, chilling medium compressor 53 compressed the chilling medium which was introduced through an inlet 64 and pumped it out through an outlet 65.

Chilling medium condenser 54 was provided outside of the passenger compartment such as an engine room. In chilling medium condenser 54, a fan 66 blew air from outside of the passenger compartment and thereby air which chilled a vapor phase chilling medium with a high temperature and a high pressure which chilling medium compressor 53 supplied only during cooling operations and thereby condensed it.

Liquid reservoir 55 temporarily stored the chilling medium which was liquefied in chilling medium condenser 54 or first heat exchanger 51 in order to supply only the

liquid phase chilling medium to first heat exchanger 51 or second heat exchanger 52 according to the cooling load.

Through their small holes, expansion valves 56 and 57 sprayed the liquid phase chilling medium with a high temperature and a high pressure which had passed through liquid reservoir 55, thereby rapidly expanding the medium and turning it into a chilling medium in a mist form having a low temperature and a low pressure.

Reverse flow check valve 58 allowed a chilling medium to pass which traveled from chilling medium condenser 54 through a chilling medium pipe 63 to liquid reservoir 55 and blocked a cooling medium which attempted to flow from first heat exchanger 51 through a chilling medium pipe 63 to chilling medium condenser 54.

Reverse flow check valve 59 allowed a chilling medium to pass which traveled from first heat exchanger 51 through a chilling medium pipe 63 to liquid reservoir 55 and blocked a cooling medium which attempted to travel from chilling medium condenser 54 through a chilling medium pipe 63 to first heat exchanger 51.

Electromagnetic valve 60 supplied a chilling medium to second heat exchanger 52 when the valve opened in heating operations. Electromagnetic valve 60 supplied a chilling medium to second heat exchanger 52 when the valve opened in heating operations, and when the valve closed in cooling operations, it prevented a chilling medium from flowing into second heat exchanger 52.

Electromagnetic valve 61 prevented a chilling medium from flowing into chilling medium condenser 54 when the valve closed during heating operations, and allowed a chilling medium to flow into chilling medium condenser 54 when the valve opened during cooling operations.

Four-way valve 62 has a function to reverse a circulating direction of a chilling medium in chilling medium pipe 63 of refrigerating cycle device 5, thereby switching between a cooling operation (solid line) and a heating operation (dashed line) of refrigerating cycle device 5.

Operations of hot water circuit 4 and refrigerating cycle device 5 of the present example will be explained based on Figure 1.

I. During a cooling operation

When a heating and cooling switch lever was turned to a cooling operation, the electromagnetic clutch turned on and engine 10 drove chilling medium compressor 53. Moreover, fan 31 and fan 66 turned on. Further, electromagnetic valve 60 closed and electromagnetic valve 61 opened.

Water valve 43 of hot water circuit 4 closed, thereby blocking a supply of the engine cooling water to hot water heater 41. Thus, high-temperature engine exhaust heat held in the engine cooling water was prevented from dissipating at hot water heater 41.

A vapor phase chilling medium having a high temperature and a high pressure which was compressed in chilling medium compressor 53 and which was pumped through outlet 65 passed through four-way valve 62 which was switched to the cooling operation side and through open electromagnetic valve 61 and flowed directly into chilling medium condenser 54. This chilling medium exchanged heat with chilled air which was blown by fan 66, was chilled, and then condensed into a liquid phase chilling medium having a high pressure.

The condensed liquid phase chilling medium passed through reverse flow check valve 58 and was blocked at reverse flow check valve 59, and then flowed into liquid reservoir 55. The chilling medium was separated into a vapor phase chilling medium and a liquid phase chilling medium in liquid reservoir 55. Since electromagnetic valve 60 was in a closed state, only the liquid phase chilling medium flowed into expansion valve 57, where it adiabatically expanded to become a chilling medium in a mist form having a low temperature and a low pressure, and flowed into first heat exchanger 51. The chilling medium which flowed into first heat exchanger 51 became a vapor phase chilling medium having a high temperature and a low pressure.

At this point, the air around first heat exchanger 51 was chilled. Fan 31 blew it through the second heat exchanger 52 which did not contribute to heat exchanging and through the outlet into a passenger compartment, thereby cooling the inside of the passenger compartment. Moreover, the vapor phase chilling medium which flowed out of first heat exchanger 51 passed through four-way valve 62 and was sucked through inlet 64 of chilling medium compressor 53.

Through repetition of the above cooling operation, the inside of the passenger compartment was cooled.

Furthermore, when electromagnetic valve 60 was open, both first heat exchanger 51 and the second heat exchanger 52 functioned as a chilling medium evaporator, thereby increasing the cooling capacity in comparison to that when only first heat exchanger 51 functioned as chilling medium evaporators. As described above, opening or closing electromagnetic valve 60 enables two ways of control: When both first heat exchanger 51 and the second heat exchanger 52 functioned as chilling medium evaporators, and when only first heat exchanger 51 functioned as a chilling medium evaporator. Thus the amount of a heat absorption by air could be controlled in two levels. When this effect was not necessary, electromagnetic valve 60 was eliminated and both first heat exchanger 51 and the second heat exchanger 52 functioned as chilling medium evaporators at all times during cooling operations.

II. During heating operation

When a user turned a heating and cooling switch lever to the heating operation position, the electromagnetic clutch turned on. Then, chilling medium compressor 53 was driven, fan 31 turned on and fan 66 turned off. Electromagnetic valve 60 opened and electromagnetic valve 61 closed. Water valve 43 of hot water circuit 4 opened.

At this point in hot water circuit 4, the engine cooling water which was heated in a water jacket of engine 10, passed through water valve 43 and flowed into hot water heater 41. Then, the engine cooling water which flowed into hot water heater 41 heated air which passed through hot water heater 41. Then, the cooling engine water in hot water heater 41 heated the air which flowed into air duct 2 as described above and then again flowed into the water jacket of engine 10.

The vapor phase chilling medium having a high temperature and a high pressure was compressed in chilling medium compressor 53 which was driven by engine 10 and then pumped out through outlet 65. Then it passed through four-way valve 62 which was switched to the heating operation side and flowed directly into first heat exchanger 51, where the medium was condensed into a liquid phase chilling medium having a high pressure. At this time, the heat from the condensation heated the air again which had been heated in hot water heater 41.

The condensed liquid phase chilling medium passed through reverse flow check valve 59, was blocked at reverse flow check valve 58 and then flowed into liquid reservoir 55. The chilling medium was separated into a vapor phase chilling medium and a liquid phase chilling medium in liquid reservoir 55. Only the liquid phase chilling medium passed through open electromagnetic valve 60 and flowed into expansion valve 57, where it adiabatically expanded to become a chilling medium in a mist form having a low temperature and a low pressure, which flowed into the second heat exchanger 52. While it passes through second heat exchanger 52, the chilling medium absorbed heat which was dissipated in hot water heater 41 from the high-temperature engine exhaust and which was carried in the engine cooling water and absorbed heat from the heated air in first heat exchanger 51. Then, it became a vapor phase chilling medium having thermal energy for heating air.

Here, the air (for example, 120°C, 200m^3/H) which fan 31 introduced into air duct 2 from outside of the passenger compartment was heated by the heat in the high-temperature engine exhaust which was carried in the engine cooling water (for example, engine cooling water with a temperature of 20°C and at 10 /m i n). While it passed through hot water heater 41, it warmed up to 10°C. Next, after it passed through hot water heater 41, the air flowed into first heat exchanger 51 which functioned as a chilling medium evaporator, in which the air absorbed heat from the chilling medium, thereby being heated to 65°C.

Next, after it passed through first heat exchanger 51, the air flowed into the second heat exchanger 52 which functioned as a chilling medium evaporator. At this time, the amount of heat absorption in second heat exchanger 52 was significantly enhanced in comparison to that of a conventional heat pump-type vehicular heating and cooling apparatus. (In a case of conventional water chilling medium heat exchanger 107, the temperature of engine cooling water is 20°C. In the case of the present example, the temperature of air coming out of the first heat exchanger was 65°C.) Thus, the work in chilling medium compressor 53 increased, thereby cooling the air from 65°C to 35°C.

In other words, by increasing the amount of heat absorption in second heat exchanger 52 functioning as a chilling medium evaporator, the work in chilling medium compressor 53 increased, and further a heat dissipation in the first heat exchanger

functioning as a chilling medium condenser increased. Therefore, the heating capacity of the present example was significantly improved in comparison to that of refrigerating cycle device 100 of the conventional heat pump-type vehicular heating and cooling apparatus. Furthermore, with a higher temperature of the engine cooling water, the temperature of air coming out to the passenger compartment could be increased.

Hence, when the engine cooling water at a temperature of 20°C and the chilling medium exchanged heat in first heat exchanger 51 and second heat exchanger 52 using air as a medium, air with a temperature of 35°C at the outlet could be pumped to the passenger compartment. Thus, unlike a heating and cooling apparatus which employs only engine cooling water as a heat source, the work by chilling medium compressor 53 was added to the chilling medium as thermal energy in the present example. Therefore, the heating capacity was increased to the sum of the amount of heat absorbed in engine cooling water and that of the work by chilling medium compressor 53. Thus, the heating capacity of the present example can be improved in comparison to that of a conventional heating and cooling apparatus.

Further, fan 31 blew the air at a temperature of 35°C into the passenger compartment through the outlet. Thus, the inside of the passenger compartment was heated. This vapor phase chilling medium was sucked through inlet 64 of chilling medium compressor 53.

Through the repetition of the above mentioned heating operation, the inside of the passenger compartment was heated.

Furthermore, in the present example, second heat exchanger 52 which functioned as a chilling medium evaporator was provided inside air duct 2 at the downstream of airflow from hot water heater 41, and the engine cooling water and the chilling medium exchanged heat using air as a medium. Therefore, even when holes appear in second heat exchanger 52 and the like, due to corrosion or another cause, the chilling medium would not flow into cooling water pipe 42.

In other words, the chilling medium pushed the engine cooling water, thereby preventing cooling water pipe 42 from coming off due to an increase of its interior pressure. Thus a leakage of the engine cooling water could be prevented. Therefore,

problems such as a failure of engine 10 caused by an insufficiency of engine cooling water could be prevented before it takes place.

Figure 2 shows a refrigerating cycle device of an automotive heat pump-type heating and cooling apparatus adopted in the second example of the present invention.

(The same reference designators are given to the items with the same function as in Figure 1.)

In the present example, a first heat exchanger 51 was provided in an air duct 2 at the downstream of a second heat exchanger 52.

Air (for example -20°C, $200m^3/H$) which fan 31 introduced into air duct 2 from outside of a passenger compartment was heated to 10°C by a high-temperature engine exhaust heat which was held in engine cooling water (for example, engine cooling water having a temperature of 20°C at 10 / min) while the air passed through a hot water heater 41. Then the air which passed through hot water heater 41 was chilled to 0°C in the second heat exchanger 52 which functioned as a chilling medium evaporator.

Next, the air, which passed through the second heat exchanger 52 was heated to approximately 25°C in first heat exchanger 51 which functioned as a chilling medium condenser. Then, the air which was heated to 25°C in first heat exchanger 51 was blown out by fan 31 through an outlet into the passenger compartment. As a result, the inside of the passenger compartment was heated. In the present example, the amount of absorbed heat in first heat exchanger 51 was smaller than that in Example 1, and therefore the heating capability were less. A temperature of air blown into the passenger compartment could be, however, made higher than that of the engine cooling water.

[Other examples]

In the present examples, a supply of the engine cooling water to the hot water heater was blocked by the electromagnetic valve while in a cooling operation. But an air mixing damper and a bypass for chilled air could be provided at the upstream of a hot water heater, thereby the air mixing dumper could block airflow to the hot water heater during a cooling operation.

In the present examples, a supply of the engine cooling water to the hot water heater was blocked by an electromagnetic valve during a cooling operation. But a bypass

pipe can be provided at a cooling water pipe to detour the hot water heater during a cooling operation and a supply of the engine cooling water could be blocked by pouring the engine cooling water into the bypass pipe. Alternatively, a bypass duct can be provided to an air duct to detour the hot water heater and during a cooling operation, the supply of air to the hot water heater could be blocked by pouring air into the bypass duct.

In the present examples, the electromagnetic valve blocked a supply of the chilling medium to the second heat exchanger during a cooling operation. However, a damper piece could be provided at the upstream of the second heat exchanger so that the dumper piece could block airflow to the second heat exchanger during a cooling operation.

In the present examples, the electromagnetic valve was provided between the four-way valve and the condenser, but the electromagnetic valve between the four-way valve and the condenser could be omitted.

4. Brief Explanation of Figures

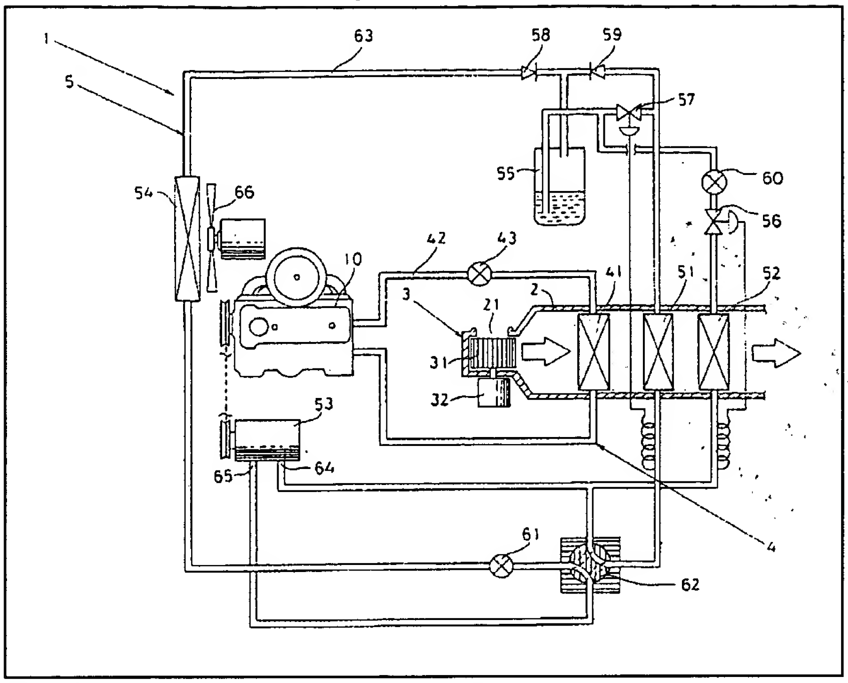
Figure 1 is an abbreviated illustration which describes a refrigerating cycle device of an automotive heat pump-type heating and cooling apparatus adopted in Example 1 of the present invention. Figure 2 is an abbreviated illustration which describes a refrigerating cycle device of an automotive heat pump-type heating and cooling apparatus adopted in Example 2 of the present invention. Figure 3 is an abbreviated illustration which describes a refrigerating cycle device of a conventional automotive heat pump-type heating and cooling apparatus.

In the figures:

1··· Automotive heat pump-type heating and cooling apparatus 2··· Air duct 5··· Refrigerating cycle device 10··· Engine 41··· Hot water heater 51··· First heat exchanger 52···Second heat exchanger

Agent: Patent Attorney: Kenji Ishiguro

Figure 1



1 Automotive heat pump-type heating and cooling apparatus

2 Air duct

5 Refrigerating cycle device

10 Engine

41 Hot water heater

51 First heat exchanger

52 Second heat exchanger

Figure 2

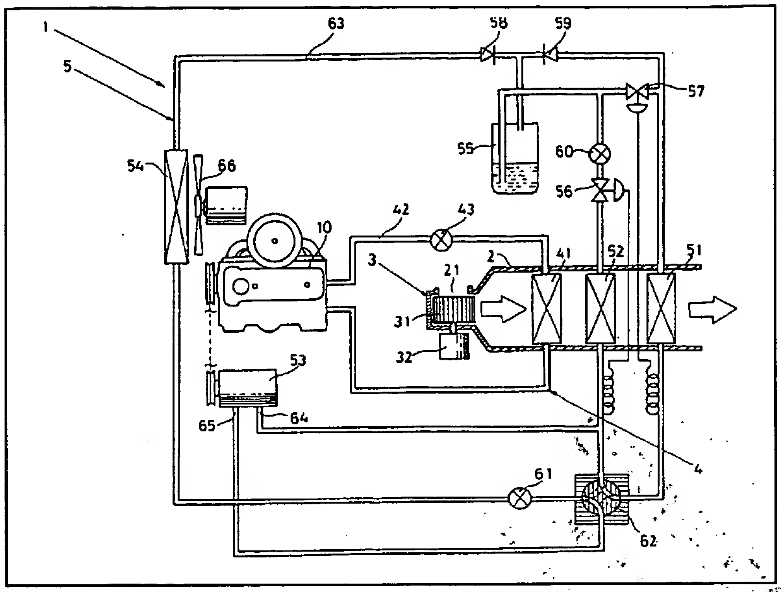


Figure 3